Soil
FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture and Food

Order No. 611.100-2
Agdex: 533
May 1991

SOIL SAMPLING IN FERTILIZER-BANDED FIELDS

INTRODUCTION

Soil sampling has followed specific guidelines which are now being challenged for a number of reasons. Extreme variability of soil nutrient levels exists within fields. Fertilizer recommendations are established on the principle of random soil sampling in a field. Deep banding nutrients at or before seeding plus the reduction in tillage can result in undisturbed residual fertilizer bands, especially phosphorus and potassium. This has been recognized by soil fertility specialists and researchers as a problem in providing fertility recommendations to producers.

Two views of this issue are reproduced in this factsheet. The first is by Dr. Robert Mahler of the University of Idaho and the second by Doug Penny of Alberta Agriculture.

1. SAMPLING METHODS

- by Roger Veseth and Dr. Robert Mahler

Little research has been conducted to determine the best method of sampling in fertilizer-banded fields. Dr. Mahler points out that an ideal sample would be a continuous soil slice 1 to 2 inches wide and 12 inches deep extending from the centre of one band to the center of the next band. **Note**: university fertilizer recommendations in the Northwest for immobile nutrients are based on a sampling depth of 0 to 12 inches). Currently, three different sampling approaches are widely used to sample fields which have undisturbed fertilizer bands. Dr. Mahler delineates them as systematic, controlled and random.

Systematic Sampling Method

To use this method, you must know the direction, depth and spacing of the fertilizer band to obtain a representative soil sample. An example could be where a no-till drill placed the fertilizer band directly below the seed row in the previous crop and the crop stubble remains undisturbed. He suggests taking 5 to 10 soil samples perpendicular to the band rows beginning at and including one band row and ending at the edge of the next band (Fig. 1). Follow this procedure on at least 20 sampling sites in each field or portion of a field being sampled. Thoroughly mix the samples from 20 or more sites together and take a composite sub-sample for analysis.

Controlled Sampling Method

As with the systematic sampling method, you also need to know the direction, depth and spacing of the fertilizer bands to obtain a representative soil sample with the controlled method. He suggests taking 20 to 30 soil cores from random sites throughout the field or uniform portion of the field but avoid sampling directly in a fertilizer band.

Thoroughly mix the soil cores and take a composite sub-sample. Dr. Mahler points out that this method of sampling may result in slightly lower soil test values of non-mobile nutrients than the systematic and random sampling methods because the fertilizer bands are not sampled.

Random Sampling Method

In some situations, the locations of the previous crops' fertilizer bands are not known. An example of this is when the fertilizer was banded in a separate operation from seeding. Because of the presence of the fertilizer bands, Dr. Mahler suggests that more samples be taken for a composite sub-sample from the area than would be necessary if the field did not contain fertilizer bands. A total of 40 to 60 cores are suggested instead of 20 to 30 cores used in the systematic or controlled sampling methods.

Field Research Results

To compare the three sampling methods, Dr. Mahler selected three growers' fields in northern Idaho in 1988. All three fields had been no-till seeded to winter wheat with the fertilizer banded directly below the seed rows. Both N and P fertilizers had been applied together in the bands. Application rates ranged from 60 to 90 pounds N/acre and from 20 to 40 pounds P_2O_5/acre. Each field was divided into six units for sampling replications.

A 1-inch diameter soil sampling probe was used to collect the cores to a depth of 12 inches. In the systematic sampling method, eight cores were taken between the fertilizer bands for composite samples from 20 locations. The first core sample was in a band and the other seven cores extended to the edge of the next band. The controlled sample method included 25 cores and the random method included 50 cores. Samples were analyzed for NO_3-N and P (NaOAc extractable).

Results for N

Dr. Mahler found no differences between the three sampling methods in determining soil N content (Table 1). Apparently, fertilizer N was sufficiently utilized by the previous crop and dispersed from the band so that all three sampling methods provided similar results.

Results for N

Different sampling methods resulted in different soil test P values (Table 2). Dr. Mahler explains that since fertilizer bands were not included in the controlled sampling method, available P level in the soil is underestimated with this method. The P soil test values with the controlled method were significantly lower than with the other two methods. The systematic method consistently resulted in the highest soil test P values at each site. Intermediate test values resulted from the random method since fewer fertilizer bands were sampled than with the systematic method.

In an actual field production situation, the differences in soil test P with the three sampling methods at these three sites could potentially have resulted in a different P fertilizer recommendation. For example, in the UI Current Information Series 453, ***Northern Idaho Fertilizer Guide for Wheat***, different P fertilizer rates are recommended at the soil test P levels of 0 to 2 ppm P compared to at 2 to 4 ppm P. No P fertilizer is recommended when the soil test P is greater than 4 ppm. Site 1 has soil test P values in both the 0 to 2 ppm and 2 to 4 ppm P soil test ranges. Sites 2 and 3 each have a soil test P value which is on the border of one these soil test P ranges.

Table 1

Summary of soil test NO_3-N to a depth of 12 inches using three sampling methods at three northern Idaho field sites where N fertilizer was banded at seeding of the previous crop, 1988 (Mahler, UI, Moscow)

Sampling Method	Site 1	Site 2	Site 3
	---------------(ppm)---------------		
Systematic	3.1	1.2	2.8
Controlled	3.2	1.0	2.8
Random	3.3	1.0	2.6
LSD*	NS	NS	NS

* Least difference between column means for statistical significance at the 95 percent probability level (NS means no significant difference).

Table 2

Summary of soil test P (NaOAc extractable) to a depth of 12 inches using three sampling methods at three northern Idaho field sites where P fertilizer was banded at seeding of the previous crop, 1988 (Mahler, UI, Moscow)

Sampling Method	Site 1	Site 2	Site 3
	---------------(ppm)---------------		
Systematic	2.9	4.0	2.6
Controlled	1.8	2.4	2.0
Random	2.5	3.4	2.4
LSD*	0.3	0.5	0.3

* Least difference between column means for statistical significance at the 95 percent probability level.

It is important to note here that in soils with a high potential to immobilize P, differences in soil test P may not be apparent with these different soil sampling techniques. Also, the increments of ppm soil test P used for determining P fertilizer rates will vary with state fertilizer guides. This can be a result of differences in the laboratory chemicals being used to extract P from the soil sample (e.g. $NaHCO_3$ with alkaline pH soils instead of NaOAc for acid pH soils), depth of soil sample required, yield potentials, soil test correlation results and other factors. Appropriate extension fertilizer guides from your respective state land-grant university should most accurately address your soil and production conditions.

Implications for Soil Sampling

Dr. Mahler concluded that for mobile nutrients such as N, all three sampling methods provided satisfactory results. The random sample method would be preferred because it is easiest to use. More samples were taken in the random method than would ordinarily be suggested for the same size of field where fertilizer had not been banded. Dr. Mahler points out that it is not clear from the research results whether sampling for soil test N in fields where N fertilizer was previously banded should not be a concern. Since results with the controlled and systematic methods were not different in this study, Dr. Mahler feels that a larger sample number with the random method is probably not necessary for mobile nutrients.

For immobile nutrients such as P, Dr. Mahler feels that the systematic sampling method provides the most accurate soil test result. However, he feels that the random sampling method with a larger number of sub-samples would probably be the most acceptable method because it is least complicated and provides a soil test P value which was relatively close to the value for the systematic method.

The application of more immobile nutrient fertilizer, possibly more than necessary, might occasionally occur when using soil test values from the random sampling method because it slightly underestimates nutrient availability compared to the systematic method. This would most likely occur when the soil test values from random sampling are borderline between different fertilizer rate recommendations on crop fertilizer guides.

Dr. Mahler is concerned that there is some uncertainty on how the soil test results for immobile nutrients should be interpreted in fertilizer requirements. He explains that most extension crop fertilizer guides developed by land-grant universities in the Northwest are based on the correlation between soil test values (from sampled fields not receiving banded fertilizer applications) and the crop response to a range of broadcast fertilizer rates. Dr. Mahler points out that new correlation research is needed to be certain that present fertilizer guides are accurate for the new fertilizer placement technology. This new information is needed both for soil test values from fields where fertilizer has been banded and for fertilizer recommendations with band applications. Unfortunately, adequate funding for this type of applied research to update fertilizer guides for the new technology is not currently available in the Northwest.

Special Considerations in Sampling No-till Fields

In fields which have an extended history of minimum soil disturbance under continuous no-till and reduced tillage systems, there can be some additional fertility management considerations. Dr. Mahler points out that if immobile nutrients have been surface broadcast, there can be an accumulation of nutrients at or near the surface. Fertilizer nutrients in the surface 1-inch of soil will probably not be available to the growing crop unless the surface soil remains moist for extended periods of time during the growing season. This is a relatively uncommon situation in the Northwest. For this reason, Dr. Mahler suggests that the surface 1-inch of soil be removed before sampling where there is a long history of minimal soil disturbance. Fortunately, broadcast applications of immobile nutrients under no-till and other conservation tillage systems are rarely used now because of wide-spread availability of new equipment to band fertilizer under conservation tillage systems.

A second concern is the reduction in pH of the surface soil with continuous no-till systems after extended periods of time, particularly in the higher precipitation areas. Increasing soil acidity can affect the availability of fertilizer nutrients as well as the activity of some commonly used herbicides, insecticides and fungicides. Dr. Mahler recommends that the pH of the surface foot be determined at 3-inch intervals (0 to 3, 3 to 6, 6 to 9, 9 to 12 inches) every 3 to 5 years.

2. SOIL TESTING – THE NEXT GENERATION

- by Doug Penney

Like most things, soil testing has undergone many technological changes over the past twenty years. The most apparent changes have been in laboratory equipment. Most analytical methods are now rapid, automated and more precise. Computers have also allowed more sophisticated approaches to interpreting soil tests and making recommendations. The question is, has the adoption of new technology improved the information available for managing soil fertility? Some would argue yes and others no. If you are on the yes side, you can legitimately argue that some progress has been made but it is difficult to make a case for a giant leap forward.

A giant leap forward may not be in the immediate cards but we can at least identify the weakest links in the current system and take the next step. I believe that field calibration of soil tests and soil sampling methods have not progressed and are currently the main limitation to improving fertility management.

Field calibration of soil tests has received very little attention in the past 20 years. In many cases, the relationship between soil tests and crop response to fertilizers has not been verified for current crop varieties and management practices (i.e., tillage systems and methods of fertilizer application).

Guidelines for sampling fields for fertility recommendations essentially haven't changed for more than forty years. The guidelines generally recommend taking 15 to 25 cores from randomly selected locations (avoiding unusual areas) and mixing them together to make one composite field sample. Increased spatial variability (change over distance) in nutrient levels caused by fertilizer banding, reduced tillage and erosion has rendered this approach less effective than when it was first developed a half century ago.

In a farm field, there can be tremendous variation in the nutrient content of individual soil cores, even when the cores are only a few inches apart. For example, a core taken from a fertilizer band may contain 5 to 10 times more phosphorus than a core from between the bands. To obtain a representative sample using a one inch diameter core tube when the fertilizer bands are 6 inches apart, one core should be taken from the band and five from between the bands. If 18 cores are taken randomly to make a composite sample, there is a high probability that less than or more than 3 will be from the fertilizer band and therefore, the composite sample will not represent the average nutrient concentration of the sampled area. If core samples are taken at random in situations where the location of the fertilizer band is not known, the only way to obtain a representative sample is to take a very large number of cores.

One alternative to taking large numbers of soil cores to get representative samples is to take "slices" of soil from across the fertilizer bands. Initial results indicate there is much less variation between samples using the "slice method" compared to the "core method." Thus a composite sample of 15 slices would be more reliable than from 15 cores. Norwest Labs is currently adapting a chain saw to conveniently take slices of soil.

The next step towards improved soil testing is to use aerial photographs, soil survey information, detailed sampling and computer mapping to map fields with respect to fertility and other soil parameters. The end result is a field management map. Some nutrients such as P and K don't fluctuate much from year to year and tend to vary in a predictable way with landscape position and soil types. Thus nutrient maps can be used to develop P and K fertilizer programs that will remain valid for several years. For example, it is not uncommon for available P levels to be very low on eroded hills and high on lower slopes where topsoil has accumulated. Varying the rate of P application to match soil conditions (more on the hills, less in the low spots) results in more uniform crop growth and higher net return on fertilizer investment.

Field management maps are also useful in developing recommendations for nutrients that vary across the field and with time. Soil tests for these nutrients, nitrogen is the prime example, must be conducted on an annual basis. A management map initially divides the field into areas using criteria that are known to affect available N levels. These areas become soil sampling units and are sampled separately. Nitrogen fertilizer recommendations are developed and applied to each sampling unit. If good records are kept, patterns should start to emerge after several years. For example, soil test N in Unit 1 tends to be half again as high as Unit 2, Unit 3 is always very similar to Unit 4 so they can be combined. With increasing time, the result should be an increasingly effective and profitable N management program.

The key to using field maps in fertilizer management is application equipment that allows the fertilizer rate to be varied from the cab. Equipment is being developed that automatically reads a field map and changes application rates according to map specifications. Such systems require an onboard computer and rely on electronic navigational systems to tell the computer where the applicator is in the field. As you have already guessed, the initial setup is going to cause a fair bit of pain in the back pocket. However, manually controlled systems are inexpensive and can be used effectively. In this low tech scenario, the operator has the map with him in the cab and varies the fertilizer application rate with the flick of a switch as he traverses the field. At least one farmer, Kirk Harold of Lamont, Alberta devised his own system by modifying a Prasco Super Seed (see Farm Light and Power – Sept '90).

Developing field maps requires some time, effort, money and expertise but they have several important uses in addition to fertility management. For example, field maps can also be used to develop soil conservation and crop protection programs.

MATERIALS FOR THIS FACTSHEET WERE TAKEN FROM:

Soil Sampling in Fertilizer Banded Fields — Roger Veseth, Pacific Northwest Conservation Tillage, Handbook No. 14, Chapter 6

Soil Testing – The Next Generation — Doug Penny, SOILutions, Vol. 1, No.3, 1990 Alberta Agriculture

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